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ON SOME CLIMATIC CHANGES RECORDED IN NEW YORK CITY

(STUDIES ON CLIMATE AND CROPS: 5)*

By HENRYK ARCTOWSKI

The meteorological observations made at the New York Central Park Observatory (Old State Arsenal, near Fifth Avenue, at 64th Street) under the direction of Dr. Daniel Draper extend from 1868 to July, 1911. This long series of meteorological records may be considered as being perfectly homogeneous. In the present paper I intend to study some of the results of Dr. Draper's observations, in continuation of my former investigation of the remarkable variation in sunshine duration in New York City.† The recorded figures for the years 1877-1911 are given in Table 1.

TABLE I.

ACTUAL HOURS OF SUNSHINE, MONTHLY AND ANNUAL, RECORDED AT THE CENTRAL PARK OBSERVATORY, NEW YORK, N. Y., FROM 1877 TO 1911.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
1877........	163	194	283	269	339	374	345	348	307	213	166	152	3153
1878........	142	143	227	239	319	322	347	317	283	270	171	156	2936
1879........	176	195	245	269	355	354	376	303	275	250	179	124	3101
1880........	161	190	185	209	379	336	330	294	261	225	158	114	2842
1881........	156	178	150	277	298	300	341	343	267	238	164	150	2862
1882........	126	183	217	226	252	314	327	280	191	177	164	155	2612
1883........	111	118	249	218	308	303	338	325	237	171	146	142	2666
1884........	120	105	160	209	270	292	241	204	268	206	158	100	2333
1885........	143	156	217	240	228	304	311	247	234	159	121	131	2491
1886........	119	144	168	202	219	244	298	287	182	175	160	121	2319
1887........	122	120	202	209	275	277	258	279	213	175	162	113	2399
1888........	136	161	187	237	154	318	298	272	178	158	135	171	2405
1889........	149	152	171	199	271	275	228	287	164	140	114	145	2295
1890........	122	107	158	246	246	256	262	227	182	131	156	136	2229
1891........	108	128	171	236	258	306	249	200	234	183	130	157	2360
1892........	121	120	191	225	233	246	291	254	234	205	105	123	2348
1893........	133	111	176	194	251	255	313	276	239	190	178	127	2443
1894........	114	121	209	199	222	269	291	254	198	167	147	141	2332
1895...	134	163	194	194	266	253	288	296	253	235	120	122	2518
1896........	144	140	197	227	361	244	270	295	211	154	114	163	2520
1897........	132	139	175	261	278	268	235	244	248	208	121	105	2414
1898........	121	138	160	182	182	319	246	267	248	179	128	132	2302
1899........	156	139	152	281	266	318	280	256	244	187	172	171	2622
1900........	159	160	220	239	290	320	334	288	228	156	134	175	2703
1901	155	215	178	141	224	363	263	257	242	249	153	149	2589
1902........	156	163	199	201	268	310	262	303	181	188	155	144	2530
1903........	136	168	191	244	323	138	335	215	251	186	188	154	2529
1904........	138	189	181	245	295	308	311	315	236	251	169	107	2745
1905........	151	184	216	239	296	297	323	273	231	226	191	117	2744
1906........	111	202	193	279	308	329	307	226	251	159	175	103	2643
1907........	99	170	219	207	248	308	343	315	181	245	113	126	2574
1908........	157	174	200	255	253	372	353	295	248	214	149	126	2796
1909........	135	147	206	195	279	316	378	306	242	224	163	161	2752
1910........	155	171	255	269	275	282	381	294	255	228	127	145	2837
1911........	127	147	237	247	321	288	328	262	242	178	179	140	2696

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* For previous papers in this series see *Bull.*, Vol. 42, 1910, pp. 270–282 and 480–495, Vol. 44, 1912, pp. 598-606 and 745–760.

† Variations de longue durée de divers phénomènes atmosphériques. *Bull. Soc. belge d'Astron.*, 1907.

These figures show a steady decrease in the yearly numbers of hours of sunshine, from the beginning of the series of observations until 1890, followed by a more or less progressive increase. The range of the variation may be best appreciated from the fact that the figure 3153 for 1877 is equivalent to a mean daily duration of eight hours and thirty-five minutes, while the figure 2229 for the year 1890, corresponds to a mean daily duration of six hours and six minutes. It is obvious that the observed difference of two hours and a half of sunshine a day must have had many practical consequences, and undoubtedly it would be possible to corroborate this by statistical data from hygienic and economic records.*

The real significance of the variations of annual data can be studied advantageously by utilizing consecutive or overlapping means. By determining all the averages of twelve consecutive monthly means one avoids the purely conventional mode of counting the year from January to December, and the succession of values then shows how an exceptionally low or an exceptionally high figure is generally only the product of a continuous tendency of decrease or increase. I have computed overlapping annual means from the monthly records of sunshine duration, atmospheric pressure and temperature. Figure 1 expresses these figures graphically. The object of this paper is to examine some of the details of these curves.

The curve of consecutive totals of sunshine shows that the decrease from the value of 1877 to the minimum of the year 1890 is marked by most characteristic ups and downs. The crests and the depressions of the ascending part of the curve, from 1890 to 1910, are less characteristic. The descent from each crest (towards the right) is generally steeper than the ascent.

After 1886 we notice groups of crests. For example, between 1890 and 1897 we see three ups and downs forming a group. Another group of two crests characterizes the variation of the figures between 1886 and 1890. The same may be said of the crests after 1898. In this case there are six and not three or four. It is difficult, therefore, to ascertain the mean duration of the crests.

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* In the case of the observations of Pavlovsk (Notice sur les variations de longue durée des amplitudes moyennes de la marche diurne de la température en Russie, *Bull. Soc. belge d'Astron.*, 1908), I have shown that changes in the mean daily variations of temperature correspond with changes of the annual values of sunshine duration. This fact is not verified by the Central Park observations. The differences of the annual mean temperatures recorded at 7 A.M. and 2 P.M. do not always follow the oscillations of the sunshine records and, moreover, from 1891 to 1908 the values of the daily variation (expressed by these differences) decrease from 9.1° to 6.5° F., which is precisely the contrary of what was to be expected.

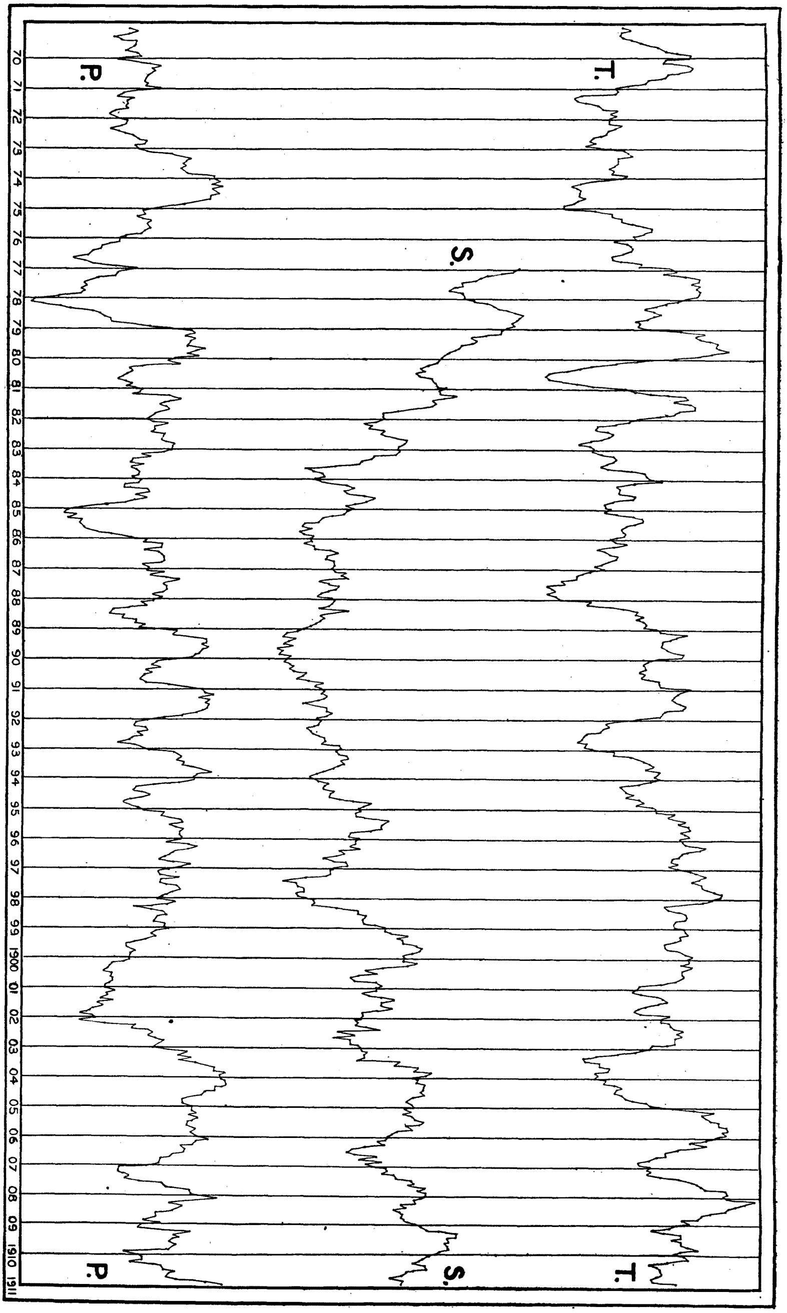

FIG. 1—Diagram of the Consecutive Totals Expressing the Variations in Temperature (T), Sunshine Duration (S) and Atmospheric Pressure (P) Recorded at the Central Park Observatory, New York, N. Y., from 1869 to 1911.

If we admit the existence of fifteen depressions we may say that they occur from sixteen to thirty-eight months apart and that the mean duration of the crests is twenty-five months.*

The amplitude of the oscillations is another feature which may be taken into consideration. The diagram gives the impression that the crests decrease up to 1892 and increase subsequently.

Considering the curves of consecutive totals of atmospheric pressure and temperature in the same way we can distinguish similar ups and downs.† From 1872 until 1910 I count eighteen depressions on the barometric curve, the intervals between which vary from eleven to fifty-four months. The mean of the intervals between the depressions is twenty-five months, which is exactly the same figure as in the case of sunshine duration. On the curve of consecutive temperatures I distinguish nineteen depressions between 1869 and 1911, the intervals varying from eighteen to forty-two months. And, in this case again, the mean duration is twenty-five months. This mean period of twenty-five months justifies the conclusion that the oscillations which we observe on these curves are primarily due to the same cause, most probably a cosmical cause.

It is, therefore, interesting to notice the lack of correspondence between the ups and downs of these curves.

Comparing the curve of sunshine duration with the curve of temperature we see that generally these two curves are inverted: that smaller durations of sunshine correspond to higher values of temperature. But in certain cases the depressions occur at the same time as the crests of temperature, and in other cases they are retarded, and sometimes it is impossible to discern any correspondence at all.

Comparing now the curve of atmospheric pressure with the temperature curve we notice a striking similarity from 1889 until 1897, showing that, exceptionally, for a short period of years, the consecutive means of pressure and temperature follow the same variations, just as it may be the case for equatorial regions. In New York, however, the annual mean of temperature is but exceptionally a function of the annual mean of atmospheric pressure.

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* The researches of H. Helm Clayton, published in the *Amer. Meteorol.Journ.* (Vol. I, 1884-85, p. 130 *et seq* and p. 528 *et seq.*) were not known to me when I wrote this paper. Clayton not only discovered the twenty-five month period but has drawn departure maps. In the future I will naturally refer to Clayton's researches and give, in one of these papers, some account of what he found.

† In Tables II and IV, I produce the observed means. These tables can serve to verify the values of overlapping totals utilized to trace the curves.

TABLE II.

MEAN MONTHLY AND ANNUAL ATMOSPHERIC PRESSURE IN INCHES RECORDED AT THE CENTRAL PARK OBSERVATORY, NEW YORK, N. Y., FROM 1869 TO 1911.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
1869..	29.941	29.881	29.956	29.813	29.723	29.890	29.887	29.955	30.063	29.874	29.889	30.068	29.909
1870..	30.005	29.812	29.834	29.864	29.857	29.881	29.875	29.911	30.035	29.990	29.908	29.869	29.931
1871..	30.117	29.969	29.910	29.797	29.879	29.846	29.854	29.902	30.021	30.012	29.901	29.978	29.935
1872..	29.912	29.872	29.883	29.914	29.836	29.842	29.842	29.915	29.922	29.970	29.937	30.010	29.904
1873..	29.981	29.866	29.848	29.821	29.906	29.887	29.907	29.964	29.983	29.956	29.853	30.037	29.917
1874..	30.060	30.059	29.887	29.938	29.863	29.866	29.931	29.917	29.999	29.998	30.064	30.045	29.969
1875..	30.105	29.981	29.976	29.850	29.879	29.914	29.856	29.924	29.916	29.873	29.953	29.908	29.928
1876..	30.017	30.008	29.916	29.881	29.945	29.891	29.859	29.948	29.863	29.856	29.825	29.864	29.905
1877..	30.013	29.922	29.864	29.869	29.874	29.883	29.830	29.827	29.958	29.923	30.006	30.036	29.916
1878..	29.936	29.843	29.847	29.726	29.818	29.828	29.848	29.778	29.993	29.898	29.828	29.852	29.850
1879..	29.899	29.941	29.988	29.803	29.993	29.885	29.885	29.829	29.996	30.032	29.999	30.048	29.941
1880..	30.049	29.960	29.913	29.884	29.952	29.879	29.876	29.958	29.925	29.969	30.083	29.854	29.942
1881..	29.999	30.054	29.620	29.778	29.975	29.832	29.846	29.913	29.997	30.023	30.029	29.993	29.921
1882..	29.977	29.980	29.926	29.871	29.876	29.766	29.893	29.933	29.939	29.967	30.008	29.947	29,923
1883..	30.032	30.106	29.807	29.875	29.846	29.883	29.870	29.928	29.968	30.035	29.996	29.945	29.941
1884..	29.965	29.935	29.880	29.715	29.835	29.991	29.761	29.966	30.009	30.023	29.943	30.020	29.920
1885..	29.943	29.818	29.888	29.899	29.846	29.874	29.855	29.866	29.942	29.882	29.782	29.857	29.871
1886..	29.913	29.923	29.806	30.016	29.829	29.896	29.873	29.894	30.031	30.052	29.873	29.979	29.923
1887..	29.893	30.071	29.803	29.870	29.953	29.919	29.894	29.891	30.004	29.908	29.919	29.969	29.924
1888..	30.026	29.960	29.915	29.996	29.901	29.841	29.923	29.897	29.962	29.837	29.988	29.910	29.929
1889..	29.905	30.008	29.777	29.868	29.880	29.951	29.915	30.000	29.949	29.921	29.954	30.027	29.929
1890..	30.077	29.985	29.904	29.997	29.883	29.919	29.965	29.946	30.037	29.781	29.927	29.919	29.945
1891..	29.903	29.952	29.973	29.877	29.926	29.866	29.946	29.930	30.075	29.970	30.061	30.057	29.961
1892..	29.917	30.026	29.860	29.958	29.895	29.889	29.941	29.891	30.932	29.843	29.914	29.927	29.924
1893..	29.831	30.005	29.955	29.968	29.816	29.937	29.857	29.869	29.928	29.988	29.977	29.979	29.925
1894..	30.036	30.023	29.993	29.931	29.878	29.917	29.937	29.946	30.007	29.873	29.953	29.994	29.957
1895..	29.910	29.803	29.858	29.908	29.951	29.981	29.865	29.864	29.946	29.907	30.042	30.032	29.922
1896..	30.078	29.787	29.871	30.044	29.962	29.879	29.916	29.930	29.919	29.900	30.057	30.023	29.947
1897..	29.972	29.948	29.943	29.972	29.851	29.848	29.879	29.887	30.029	30.034	29.960	29.955	29.939
1898..	29.884	29.957	30.102	29.827	29.847	29.897	29.959	29.915	29.963	29.999	29.923	29.912	29.932
1899..	30.026	29.898	29.832	29.961	29.938	29.935	29.880	29.903	29.950	30.090	29.916	29.946	29.939
1900..	29.920	29.867	29.863	29.883	29.853	29.863	29.885	29.940	29.978	30.061	29.908	29.939	29.913
1901..	29.871	29.784	29.835	29.868	29.820	29.934	29.878	29.956	29.972	30.039	29.867	29.938	29.896
1902..	29.955	29.713	29.845	29.816	29.917	29.813	29.917	29.870	29.960	29.953	29.972	29.954	29.890
1903..	29.830	29.915	30.102	29.779	30.049	29.855	29.874	29.921	30.042	29.924	29.942	29.918	29.928
1904..	29.983	30.041	30.025	29.897	29.934	29.982	29.956	30.002	30.044	30.014	29.888	29.933	29.975
1905..	30.008	30.051	30.036	29.802	29.930	29.905	29.925	29.921	29.971	30.017	29.924	29.972	29.955
1906..	30.013	30.081	29.976	29.880	29.893	29.866	29.912	29.951	30.013	29.971	29.950	29.996	29.958
1907..	30.103	29.973	29.968	29.791	29.912	29.867	29.821	29.932	29.937	29.962	29.943	29.901	29.925
1908..	29.876	29.968	30.013	29.850	29.873	29.985	29.999	29.960	30.037	30.062	29.945	29.959	29.959
1909..	30.031	29.849	29.734	29.972	29.855	29.912	29.872	29.952	30.036	29.968	30.073	29.813	29.922
1910..	30.002	30.006	29.989	29.855	29.893	29.859	29.852	30.004	30.019	29.928	29.709	29.927	29.920
1911..	30.037	29.999	29.897	30.041	29.967	29.870	29.936	29.969	29.995	30.009	29.942	30.062	29.977

I will now examine the barometric data more in detail. On Table II I reproduce the monthly means of atmospheric pressure recorded from 1869 until 1911.

By computing for each month the differences between the highest and lowest observed mean we obtain the following figures:

January……	0.287	May ………	0.326	September….	0.200
February……	.393	June……….	.178	October.:…..	.309
March……..	.482	July.:……….	.238	November ….	.374
April………	.329	August…….	.226	December ….	.255

These figures express approximately in thousandths of an inch the range of possible variation. I say approximately because for a longer series of observations some or all of these figures would be slightly increased. But such as they are, they lead to the following deductions: The summer months and especially the months of June and September have the most constant means; the months of December and January form a secondary minimum, whereas the highest ranges of possible variation occur in March and November. In New York it is therefore at the end of autumn and at the end of winter that the greatest differences may occur: the barometric conditions of these months are the least likely to be constant from one year to another.

I have also computed the means of atmospheric pressure for the four decades from 1871 to 1910. These are given in Table III in the form of monthly means expressed in departures from the yearly means, for each of the four decades from 1871 to 1910. The differences between these figures demonstrate the non-existence of a "normal" yearly variation. For the months of January, February and March, for example, the range of the departures is, respectively, .076, .070 and .107. Therefore, for these months the means of the forty years would be purely illusory "normal" values.

TABLE III.

DECADE	INCHES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1871–1880.	29.921	+.088	+.021	—.008	—.073	—.027	—.049	—.052	—.025	+.037	+.028	+.024	+.042
1881–1890.	29.923	+.050	+.061	—.090	—.035	—.041	—.036	—.044	.000	+.061	+.020	+.021	+.034
1891–1900.	29.936	+.012	—.009	—.011	—.003	—.044	—.035	—.030	—.029	+.047	+.030	+.035	+.040
1901–1910.	29.934	+.033	+.004	+.017	—.083	—.026	—.026	—.034	+.013	+.069	+.050	—.013	—.003

This cannot be said of the summer and autumn months, and the September maximum, in particular, may be considered as being perfectly characteristic.* This is also true if we take individual years (cf. Table II). Indeed, the highest monthly value falls thirteen times in September, twelve in August, and nine in November. The location of the minimum of the yearly variation is less well defined. April has most frequently the lowest monthly mean of the year (eleven times), then comes March (seven times), then May (six times). But the minimum occurs also as early as February (five times) or as late as October and November. This fact leads to the conclusion that, in the case of New York, the annual variation of atmospheric pressure must be very greatly affected by these more or less irregular disturbances which are graphically demonstrated on the curve of consecutive means.

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* In a paper on the yearly variation of the distribution of atmospheric pressure in North America, to be published shortly, the cause of the appearance of the September maximum will be easily explained by comparing the maps I have drawn.

It is easy to be convinced that this is really the case by tracing diagrams of monthly means for typical examples of crests and depressions of the curve of consecutive means.

In my first paper on climate and crops I have already shown how curves of consecutive means may be applied to the study of the maps of annual departures. Evidently the oscillations of the curve of New York must correspond to waves, which, on the map, are expressed in form of hyper- and hypo-pressure areas. These waves displace themselves. It is therefore interesting to notice that, for New York, these abnormal changes may equal or may even be more important than the seasonal oscillations.

In the following table (Table IV) I reproduce the monthly and annual means of temperature:

TABLE IV.

MEAN MONTHLY AND ANNUAL TEMPERATURE (F.) RECORDED AT THE CENTRAL PARK OBSERVATORY, NEW YORK, N. Y., FROM 1869 TO 1911.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
1869......	35.07	34.47	34.77	49.24	57.70	69.28	72.82	71.75	65.60	50.89	40.34	34.71	51.45
1870......	37.49	31.27	34.09	50.70	60.86	72.85	76.55	75.25	67.64	56.71	45.49	34.13	53.58
1871......	28.30	30.20	44.16	52.02	60.40	68.21	72.32	73.64	60.82	55.60	38.82	29.15	51.12
1872......	28.78	29.85	30.53	49.35	61.48	71.22	77.47	75.55	66.44	53.21	40.99	26.70	51.02
1873......	28.58	29.53	35.71	46.69	58.80	70.33	75.43	72.00	65.38	55.79	37.01	36.52	50.98
1874......	34.20	31.26	37.10	41.11	58.81	70.10	73.94	70.25	67.02	55.12	43.36	33.84	51.36
1875......	23.84	25.17	34.10	43.08	60.11	69.19	74.04	72.93	63.95	53.55	39.27	33.86	49.45
1876......	36.55	31.79	34.36	47.04	60.22	73.53	79.44	75.15	63.74	50.58	45.19	24.94	51.87
1877......	27.73	36.99	35.84	47.72	59.64	70.20	75.04	75.37	66.93	58.83	44.54	37.36	52.76
1878......	30.26	32.20	44.14	53.27	59.43	67.71	77.84	74.20	68.30	58.69	43.76	32.77	53.52
1879......	26.90	27.95	39.95	48.42	63.33	70.24	75.03	72.03	63.31	60.33	43.41	37.32	52.35
1880......	39.62	37.20	36.47	50.02	67.91	73.14	74.90	72.65	67.10	53.62	38.72	26.53	53.22
1881......	24.71	28.69	26.74	46.30	62.29	65.17	73.69	73.82	73.44	58.84	45.16	39.44	52.37
1882......	28.77	35.21	40.40	47.65	56.56	71.82	75.79	73.42	67.14	57.08	39.19	30.59	51.97
1883......	25.18	30.24	32.72	47.10	61.13	73.98	74.46	70.40	62.59	52.20	43.74	31.98	50.48
1884......	24.69	34.01	37.67	48.13	59.82	71.25	71.93	73.71	72.03	57.70	44.30	33.64	52.42
1885......	29.41	22.74	30.62	49.39	59.86	70.96	78.49	72.35	64.38	54.11	44.93	35.70	51.08
1886......	26.79	27.45	37.60	52.87	60.18	68.03	74.83	70.19	65.25	54.90	44.56	29.59	51.02
1887......	29.09	32.02	32.25	46.33	63.75	69.60	78.18	70.01	61.82	52.17	41.40	33.81	50.87
1888......	22.97	29.30	29.99	46.03	58.02	70.85	70.71	72.56	62.81	48.61	45.45	34.74	49.33
1889......	35.74	27.75	39.74	51.21	63.53	70.47	73.21	70.55	65.16	49.72	44.74	39.97	52.65
1890......	37.62	37.93	35.59	49.07	60.25	70.08	73.12	72.74	67.13	54.50	43.91	29.90	52.65
1891......	33.82	36.48	35.78	49.73	57.77	71.38	72.39	75.45	71.56	54.71	44.26	42.25	53.80
1892......	31.49	33.44	34.16	48.84	59.16	73.54	74.93	74.26	64.65	53.03	43.39	32.22	51.75
1893......	23.66	29.35	35.52	46.37	58.15	68.14	73.61	73.54	63.27	56.18	42.87	34.46	50.42
1894......	33.50	28.60	42.70	49.20	60.90	70.40	74.90	70.50	68.80	55.30	41.50	36.70	52.70
1895......	29.70	24.10	35.30	50.00	62.40	72.80	72.50	75.60	70.80	52.40	47.80	38.10	52.60
1896......	29.80	31.90	32.60	52.30	67.00	69.80	76.80	76.10	67.20	53.80	49.90	34.20	53.40
1897......	30.80	33.10	40.80	50.50	61.40	67.40	75.90	73.20	66.90	56.50	46.00	38.20	53.40
1898......	35.20	35.70	45.60	47.70	58.30	71.10	76.00	75.30	70.20	59.40	45.50	34.50	54.50
1899......	31.40	27.80	37.80	49.50	62.30	74.10	76.20	75.10	66.10	58.60	46.00	38.10	53.50
1900......	31.80	30.20	33.30	49.90	59.60	70.40	76.40	76.20	70.50	61.20	49.10	36.20	53.70
1901......	32.50	26.30	38.30	47.70	57.30	70.50	77.70	74.90	68.10	55.90	39.60	35.60	52.00
1902......	30.60	29.70	44.40	50.50	58.90	66.80	72.70	71.90	66.70	58.10	51.60	32.50	52.80
1903......	30.30	33.10	44.70	51.90	62.80	64.20	74.60	69.00	67.00	58.00	42.10	31.50	52.40
1904......	25.20	25.30	36.40	46.60	63.40	70.10	74.60	72.90	66.70	53.70	42.40	30.30	50.60
1905......	29.30	24.70	40.30	49.90	61.40	69.80	77.00	74.20	69.60	59.30	44.10	38.80	53.20
1906......	38.30	32.80	35.60	51.60	63.00	73.50	77.00	77.10	70.10	57.50	45.50	34.10	54.60
1907......	34.90	25.90	42.50	46.60	56.20	68.50	77.40	73.40	66.90	52.60	46.20	38.70	52.40
1908......	33.40	27.40	41.40	52.20	63.40	72.90	79.80	75.70	68.50	60.80	46.70	37.50	54.90
1909......	34.70	37.70	37.80	48.40	61.00	72.10	73.50	72.20	66.80	54.50	49.50	32.40	53.30
1910......	31.20	30.00	43.00	55.10	61.10	68.70	77.20	72.10	69.40	58.80	42.30	30.00	53.30
1911......	36.30	31.30	34.70	47.80	64.10	69.80	77.60	72.80	67.60	56.20	42.70	39.40	53.40

At the first glance at these figures one notices the tendency of increase toward the end of the table. The year 1908 has the highest recorded mean and the year 1888 the lowest. The difference of these mean temperatures is 5.6° F. The mean temperature of the decade 1881-1890 is 51.4°, whereas the means of the two following decades are 53.0°.

To illustrate more plainly the increase of temperature I have computed the means of consecutive *lustra*. On Figure 2 these figures are expressed graphically together with those obtained in the same way from annual means recorded in Warsaw and Batavia. The degrees Centigrade have been transformed into degrees Fahrenheit to allow of easier comparison.

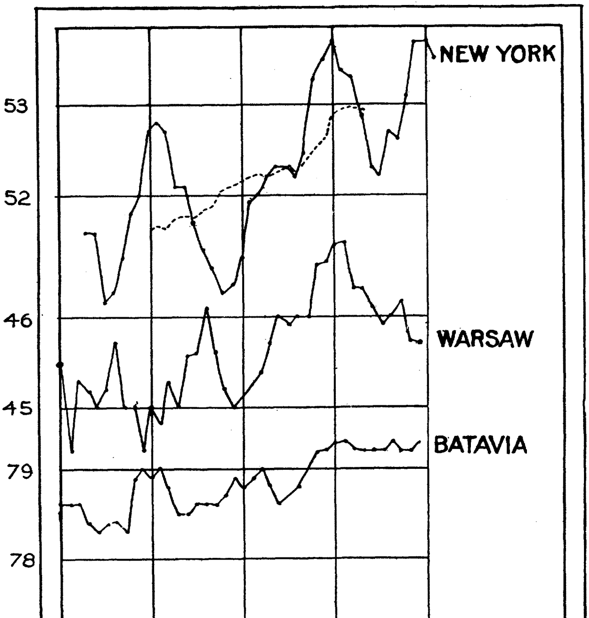

FIG. 2

The increase of temperature for New York is certainly partially due to the influence of the increase in the size of the city. But to ascertain exactly to what extent the growing city has influenced the recorded temperatures is a very difficult problem. In my paper on the secular variation of the climate of Warsaw* I have already referred to this question. Now, if one compares the curve of the temperatures recorded in Warsaw with the curve of New York, the similarity of these two curves for the periods from 1882-86 to 1903-07 is most remarkable. The ascent of the two curves is also practically the same. For Batavia, which is an equatorial station, it is smaller.

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* *Prace matematyczno-fizyczne*, Warsaw, 1908.

The fluctuations of the curve of New York are smoothed out in the consecutive mean curve of groups of twenty years, represented on Figure 2 by a dotted line.

A comparison of the curve of consecutive monthly means (T in Fig. 1) with the five-year and twenty-year mean curves, immediately shows that the length of the records is insufficient to permit any study of long-range periods and secular variations. The curve of consecutive monthly means shows plainly how irregular the short variations are. The waves of a mean duration of twenty-five months differ very greatly one from another in amplitude as well as in the length of time they cover.

The same must be the case with those variations for which the difference between the two characteristic crests of the curve of the five-year means for New York is nineteen years, and I think that it could not be otherwise with the long range variations of the ascending curve of twenty-year means.

The crests and depressions of the curve of consecutive monthly means evidently correspond to pleions and anti-pleions† of my maps of annual departures of temperature. The maps of North America, for the years 1891 to 1900, have been published in my "Enchaînements des variations climatiques" (Brussels, 1909), those for the years 1900 to 1909 for the United States and Canada have not been completed: they will be discussed later, in one of these studies on climate and crops, together with a series of curves of consecutive means for different localities.

On the curve of consecutive monthly means (Fig. 1) we notice the drop of temperature from 1891 to 1893. On the map for 1891 published in the work just cited (Fig. 34, p. 100), a pleion covered Canada, and the center of a very extensive anti-pleion was located in Kansas. In Dodge, Kan., the departure from the ten-year mean was −1.0° C. Therefore, on a curve of consecutive means for that locality we would have had a depression corresponding to the crest of New York. The following year, the drop of temperature in New York is evidently due to the advance of the anti-pleion, as the map for 1892 in the same publication shows plainly. In 1893 the center of the anti-pleion was in Winnipeg; the center of the pleion in Texas. This pleion spread out and its center moved northward in 1894: hence the ascent of the values of consecutive means in New York.

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† For definition of these terms see the first paper of this series, *Bull.*, Vol. 42, 1910, p. 271.—Ed.

The maps show that, during these four years, a variation precisely reversed from the curve of consecutive means of New York must have been observed in Arizona or New Mexico. In order to verify this conclusion I made consecutive means for Santa Fé, N. M., and found a confirmatory result. The question now arises how a passing pleion (a crest of the curve) or a passing anti-pleion (a depression of the curve) may affect the mean temperatures of individual months.

To answer this question I have collected a great amount of material, the discussion of which will be deferred to a later occasion.

The first sub-question to be taken into consideration is the range of possible variation. From the tables of mean monthly temperatures observed in New York during the years 1822-1869 and 1869-1911, I computed the differences between the highest and lowest values. For January, for example, the highest observed monthly mean is 39.6°, the lowest 22.2°, the difference is 17.4°. The figures for the different months of the year are, in chronological sequence, beginning with January: 17.4°; 19.8°; 18.9°; 14.0°; 15.2°; 14.8°; 11.8°; 11.5°; 12.7°; 15.4°; 14.6°; 20.0°. We notice, therefore, much higher values from December to March than from July to September. For New York, the summer months are the months for which the mean temperatures are bound to be the most alike from one year to another. I say expressly in New York because it is not so everywhere. In Australia, for example, it is exactly the contrary. The curves of possible range of variation are different in the different parts of the world, and they are particular to certain types of climate.

The above figures lead us to the conclusion that in New York the passing pleions and anti-pleions may have a greater effect on the winter than on the summer temperatures. In Australia the reverse is the case.

The following figures (Table V) are monthly departures for 1903, 1904 and 1905 from the corresponding monthly means of the decade 1901-1910:

TABLE V.

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1903	—1.8°	+3.8°	+4.3°	+1.9°	+2.0°	—5.5°	—1.5°	—4.3°	—1.0°	+1.1°	—2.9°	—2.6°
1904	—6.9°	—4.0°	—4.0°	—3.4°	+2.6°	+0.4°	—1.5°	—0.4°	—1.3°	—3.2°	—2.6°	—3.8°
1905	—2.8°	—4.7°	—0.1°	—0.1°	+0.6°	+0.1°	+0.9°	+0.9°	+1.6°	+2.4°	—0.9°	+4.7°

These figures correspond to a most characteristic depression of the curve of consecutive means. This depression contains two small crests. The departures of Table V show the significance of these small auxiliary crests. From February to May, 1903, we have positive departures: these months were warmer than the ten-year means; in particular, the mean of March was 4.3° too high. Then we notice a sudden drop of temperature; June is 5.5° and August 4.3° below the average. Another period of cold extends from November, 1903, to April, 1904, with a January temperature of 6.9° below the average. Then May is too warm and from May on the monthly means fall progressively lower and lower below the average until February, 1905. The conclusion is, therefore, that this very characteristic anti-pleion, was composed of groups of cold months: it was not one wave but a group of waves.

A further analysis would require the study of the daily records, the study of the entire succession of temperature waves. On the ocean we notice ripples, waves, groups of waves, the swell, and tidal waves. There is some similarity between the different sorts of waves of the sea and the oscillations of temperature.

In the following table (Table VI), I give the monthly means of temperature for decades of years, in the form of departures from the corresponding annual means:

TABLE VI.

DECAD	MEAN	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
1871–1880..	51.8°	-21.3°	-20.6°	-14.6°	-3.9°	+9.2°	+18.6°	+23.7°	+21.6°	+13.5°	+3.7°	-10.3°	-19.9°
1881–1890..	51.4°	-22.9°	-20.9°	-17.1°	-3.0°	+9.1°	+18.8°	+23.0°	+20.5°	+14.8°	+2.6°	-7.7°	-17.5°
1891–1900..	53.0°	-21.9°	-21.9°	-15.7°	-3.6°	+7.7°	+17.9°	+22.0°	+21.5°	+15.0°	+3.1°	-7.4°	-16.5°
1901–1910..	53.0°	-20.9°	-23.7°	-12.6°	-3.0°	+7.8°	+16.7°	+23.1°	+20.3°	+15.0°	+3.9°	-6.0°	-18.9°

This facilitates the comparison of the figures. Indeed, we notice immediately some sort of shifting of the yearly variation, because the February departures increase in negativity whereas the September departures increase in positivity. May and June also display a tendency to become cooler.

In order to show another curious peculiarity of the changes in the yearly variation of temperature (if considered by groups of years) I give below (Table VII) the differences of the *lustrum* means for January plus February and July plus August, the coldest and the warmest months of the year.

TABLE VII.

MONTHS.	*1869-1873*	*1874-1878*	*1879-1883*	*1884-1888*	*1889-1893*	*1894-1898*	*1899-1903*	*1904-1908*
Jan.+Feb..	31.35°	31.00°	30.45°	27.85°	32.73°	31.24°	30.37°	29.72°
July+Aug..	74.29°	74.82°	73.62°	73.30°	73.38°	74.68°	74.47°	75.91°
Diff.........	42.94°	43.82°	43.17°	45.45°	40.65°	43.44°	44.10°	46.19°

The variation of the July plus August temperatures is interesting: they decrease from the *lustrum* 1874-1878 to 1884-1888, and from then on show a very marked increase. The January plus February mean temperatures show a break of continuity between 1884-88 and 1889-93. The differences, or annual amplitudes, show this break more plainly.

Taking into account single years and computing the differences between the warmest and coldest month, for each year, we notice in these figures a striking tendency of increase from 1869 to 1888. Then comes the break, and from 1890 to 1908 we notice increasing differences. But this increase is far from being regular.

Returning now to the question of traveling pleions and their influence upon the monthly means, it is clear that everything would be simple if the pleions would pass by New York at regular intervals, of, let us say, twenty-five months, and if they would always follow the same direction and be of regular, never changing amplitude. Then, indeed, the seasonal variation of temperature being also presumably perfectly regular, the pleionian anomaly would transpose itself by nearly a month every second year, and long in advance we would know if the winter, the spring or the summer of a particular series of years would be colder or warmer than it ought to be.

But since this is not the case and since, on the contrary, every temporary anomaly is the product of the coadjustment of many variable factors, one must be astonished that the changes in the yearly variation of temperature are not more irregular than they are and that, on the contrary, they present some systematic particularities.[*]

Considering now all that I have said about the climatic changes recorded in New York City as being a parenthesis between my article on the variations of atmospheric temperature at Arequipa (*Bull.*, Vol. 44, 1912, pp. 598-606) and the researches which I am pursuing at present on the temperatures recorded in the United States from 1900 to 1909, I will correlate these two subjects by giving the curves of consecutive means for several stations along the Atlantic Coast.

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[*] Referring to the figures of Table IV for the values for individual months, the September temperatures subsequent to 1894 are seen to fluctuate between 66.1° and 70.8° whereas from 1869 to 1880 they ranged from 60.8° to 68.3°. The temperatures of the month of February show a decreasing tendency from 1877 to 1905. The July temperatures are most interesting: they show an increase from 1888 to 1901, and a new progressive increase from 1902 to 1908. The differences, December minus January and more especially August minus July, represented graphically on a diagram, display really curious tendencies of variation.

On the accompanying diagram (Fig. 3) I reproduce the temperature curves of Key West, Tampa, Savannah, Raleigh, Washington, New York, Portland and Eastport, together with the curve of Arequipa for the decade 1900-1910.

The Arequipa curve descends; all the others, on the contrary, are ascending curves. This contrast leads to the conclusion that the pleionian crests are independent of the long-range variations. Annual departures from a ten-year mean may therefore lead to very erroneous conclusions. For Arequipa, for example, the annual means for 1901 and 1902 are higher than the average of the decade taken into consideration; they form positive departures although belonging to a depression of the curve. This is a strong argument against using such departures without considering at the same time the trend of the curves. Now, the Arequipa curve has four crests and four depressions. So has the curve of New York. The most important difference between the two curves is that the maxima and minima of the curve of New York occur a few months later than those of Arequipa. One may say about three months later.

All the other curves are identical with the curve of New York in some particulars. For example, the depression of 1904 appears on all curves. It occurs sooner in Tampa and Savannah than in Raleigh, Washington and New York. In Portland, and even more so in Eastport, this depression is very much retarded. The first crest in the Eastport curve, furthermore, reappears, although greatly diminished, in the first depression of New York, which latter corresponds to that of Arequipa. One can follow the gradual attenuation of this feature going south. For 1902 we have a positive departure in Eastport belonging to a pleion. This pleion (1901-1902) has evidently nothing in common with the equatorial variation of Arequipa and other tropical stations. It is another wave having another origin and whose occurrence is marked all along the Atlantic Coast in the midst of the anti-pleionian deficiency of temperature.

After 1905 the curves of the southern stations differ greatly from the Arequipa curve. The curves of the northern stations, on the contrary, are similar to the curves of Arequipa and New York,

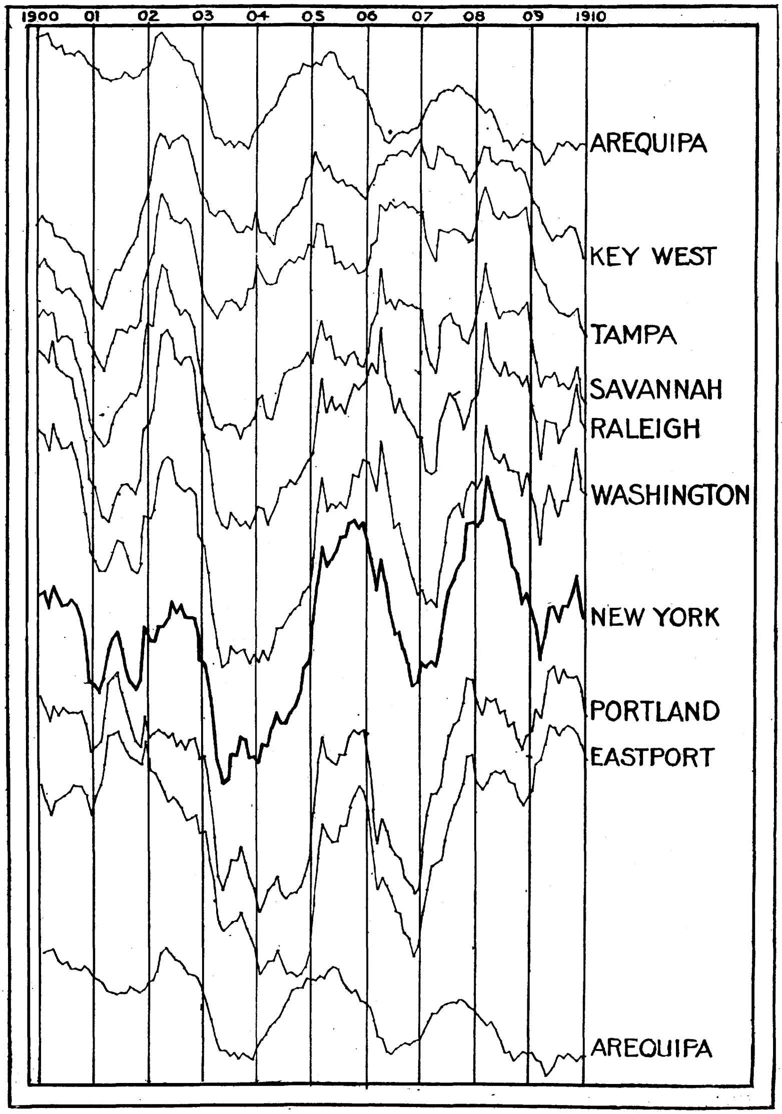

FIG. 3—Consecutive Temperature Curves, for the Years 1900–1910, of Several Stations in the Eastern United States Compared with that of Arequipa, Peru.

except at the end. In Eastport we indeed notice a crest between 1909 and 1910 which is not a retarded crest, and, going south, we observe the same attenuation of this phenomenon as between 1901 and 1902.

One may ask if the consecutive temperature curve of New York always follows the equatorial variation. A comparison with the curve of Batavia, at least, for the years previous to 1900, shows some similarities but also some striking differences.

Dobbs Ferry, N. Y., Sept. 30, 1912.

GEOGRAPHICAL RECORD

AMERICAN GEOGRAPHICAL SOCIETY

Annual Meeting of the Society. The annual meeting of the Society was held at the Engineering Societies' Building, No. 29 West 39th Street, on Tuesday, Jan. 21, 1913 at 8.30 o'clock. Vice-President Greenough in the Chair. The following persons recommended by the Council were elected Fellows:

Hiram Bingham,
Henry A. Budd,
French E. Chadwick,
Nicholas E. Crosby,
Charles B. Curtis,
Preston Davie,
John H. Emanuel Jr.,
Albert Gallatin,
Arthur W. Hart,
William R. Hearst,
Richard R. Hice,
Thomas McD. Hills,
Miss P. R. Kautz-Eulenburg.
Adolph Kuttroff,
Hopper Lenox Mott.

Dr. Francisco P. Moreno of Buenos Aires was elected a corresponding member.

Report of the Council

The Annual Report of the Council was presented and read:

January 16, 1913.

To the American Geographical Society:

The Council respectfully submits the following report for the year 1912:

The number of Fellows on January 1st was 1,173. The additions have been 101; the losses by death, resignation, etc., 115; and the total Fellowship on December 31 was 1,159, of which number 365 are Life Fellows.

There have been added to the Library 1,620 books, 3,953 periodicals and pamphlets, 1,194 maps and 17 atlases.

There were published in the *Bulletin* besides the Geographical Record, the Book Reviews, Map Notices and Bibliographical Lists, sixty-one papers, all but two of which were original contributions. The index to the volume for 1912, over 100 pages in length, is a comprehensive record of the geographical literature and cartographic products added to the library and map room during the year.

Seven meetings of the Society were held, at which addresses were made by Charles Wellington Furlong, Mura Bayly, Lieut. Charles F. Gammon, W. S. C. Russell, George Kinney, Leon Dominian and Miss Marion Cock.

The Charles P. Daly Medal was awarded to Captain Roald Amundsen in recognition of the value of his magnetic observations in the American Arctic, the achievement of the Northwest Passage and the attainment of the South Pole.